Meteorological Measurements made during RxCADRE

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Overview

- **Instrumentation and Experimental Design**
  - Overview of CSU-MAPS
- **Data Processing**
- **Preliminary Results**
  - Tower measurements: Fire front micrometeorology
  - Doppler wind lidar measurements
- **Summary and Conclusions**

California State University-Mobile Atmospheric Profiling System (CSU-MAPS)

NSF sponsored, joint-university (SFSU-SJSU) facility that provides:

- Surface-layer measurements and tropospheric profiling
- Fast deployment using a highly-mobile platform
- Measurements for a range of boundary layer applications

SF STATE

NSF

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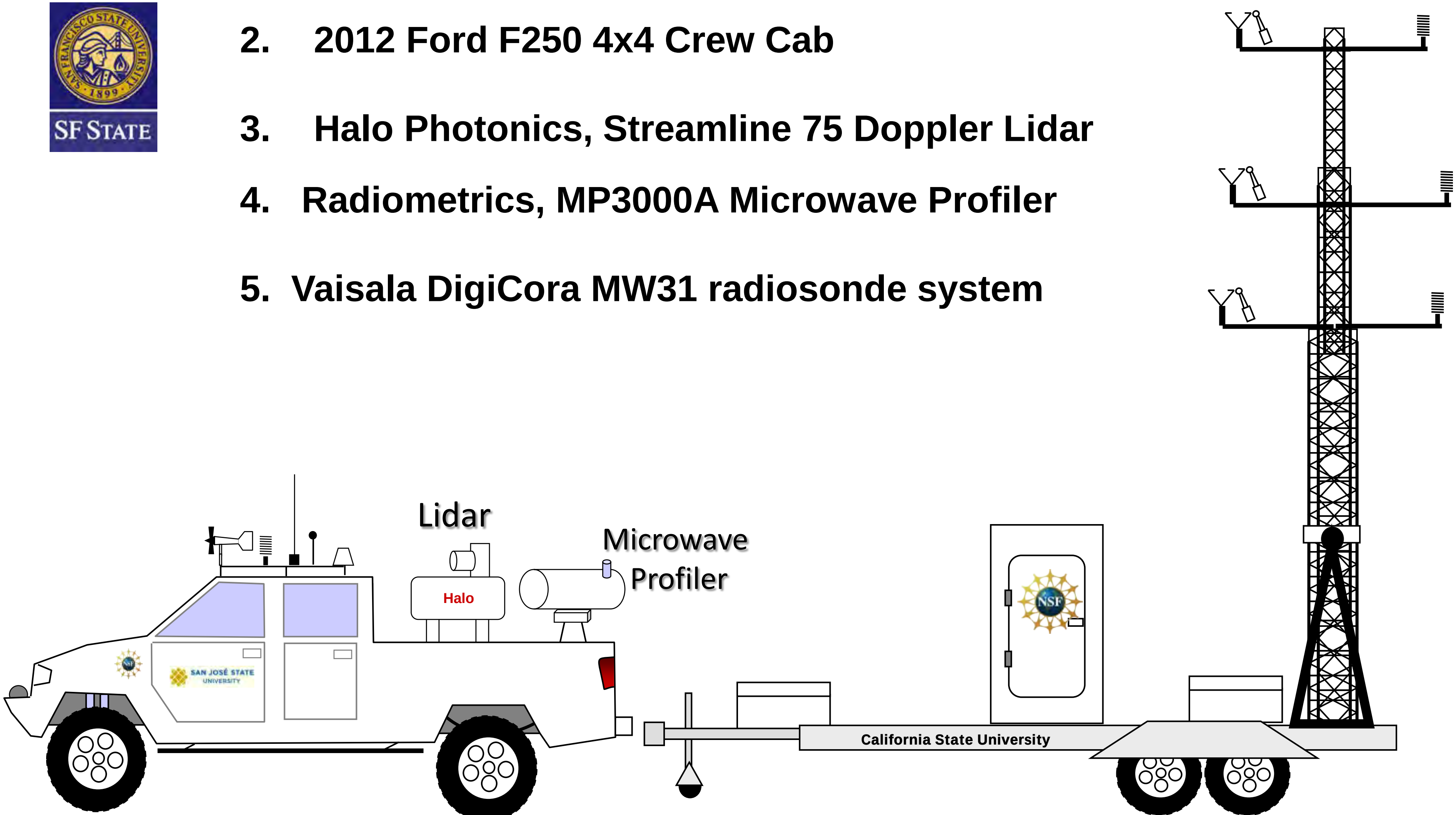
California State University-Mobile Atmospheric Profiling System (CSU-MAPS)

1. 32-m extendable meteorological tower.
2. 2012 Ford F250 4x4 Crew Cab
3. Halo Photonics, Streamline 75 Doppler Lidar
4. Radiometrics, MP3000A Microwave Profiler
5. Vaisala DigiCora MW31 radiosonde system



California State University-Mobile Atmospheric Profiling System (CSU-MAPS)

TowerWorx, MAG-106 steel tower-trailer

- GVW: 8200 lbs
- 32 m maximum height
- deploys with 2-persons, ~30 min
- uses outriggers, no guying
- instruments prewired


DRESSTA

CSU-MAPS Tower instrumentation

Up to 6 measurement levels:
four fixed: 9,15, 22, 32 m AGL

Sensors:
- HMP45C Temp/RH sensor

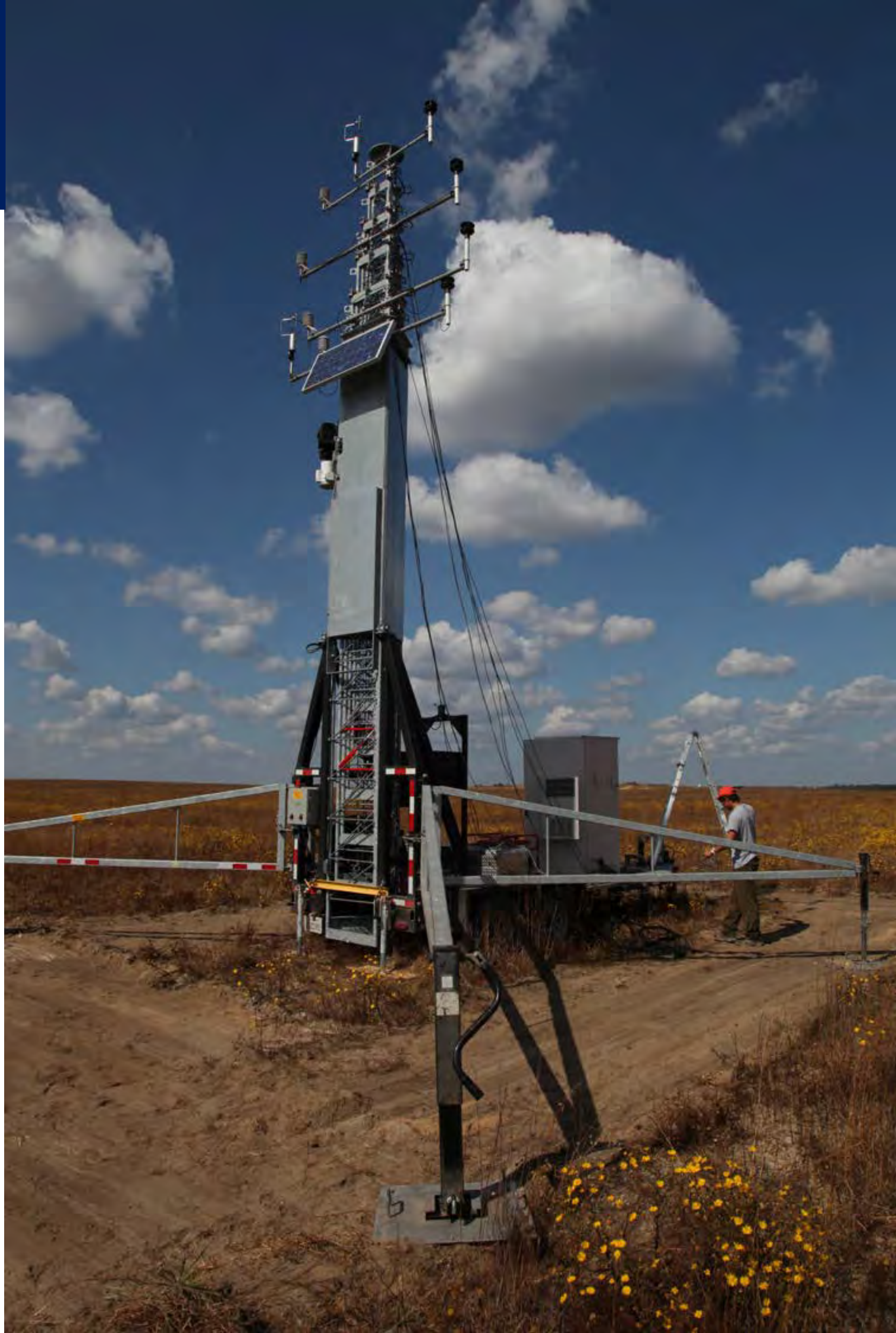
- Gill 2-D windsonic anemometer

- CSI CSAT 3-d sonic (two)

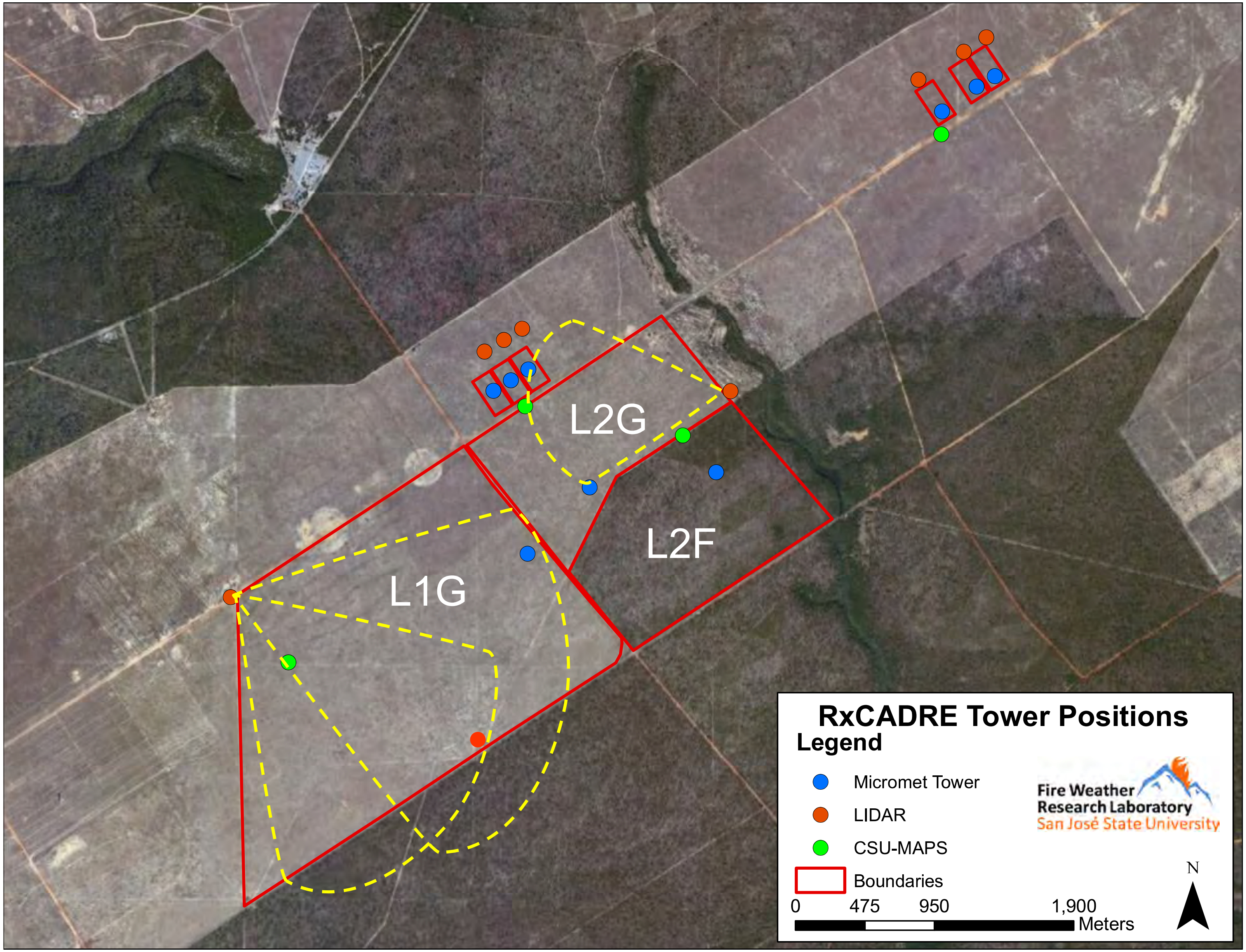
- Licor 7500 CO_2/H_2O analyzer

- CSI CR1000, CR3000 loggers

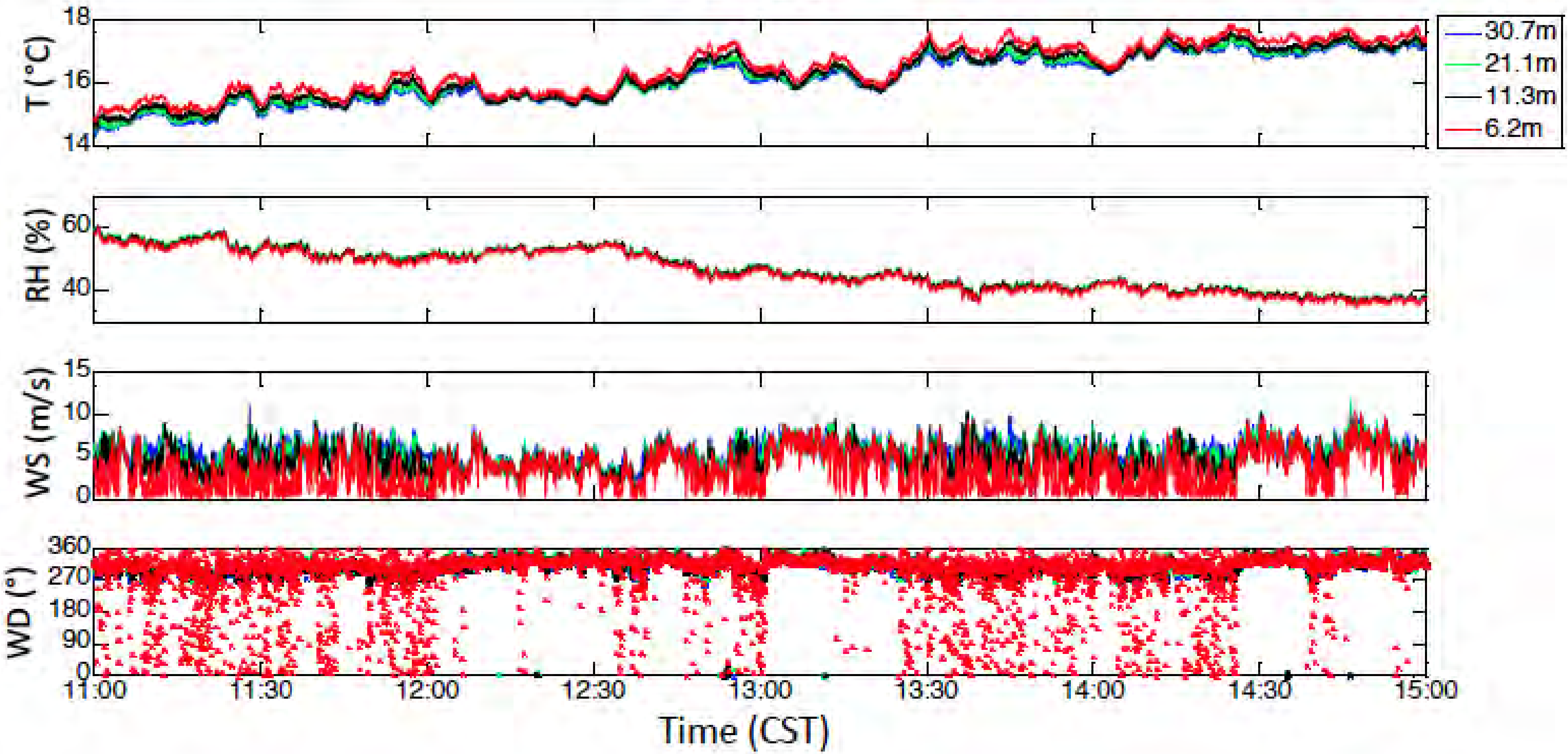
- Powered by 70 W Solar panel



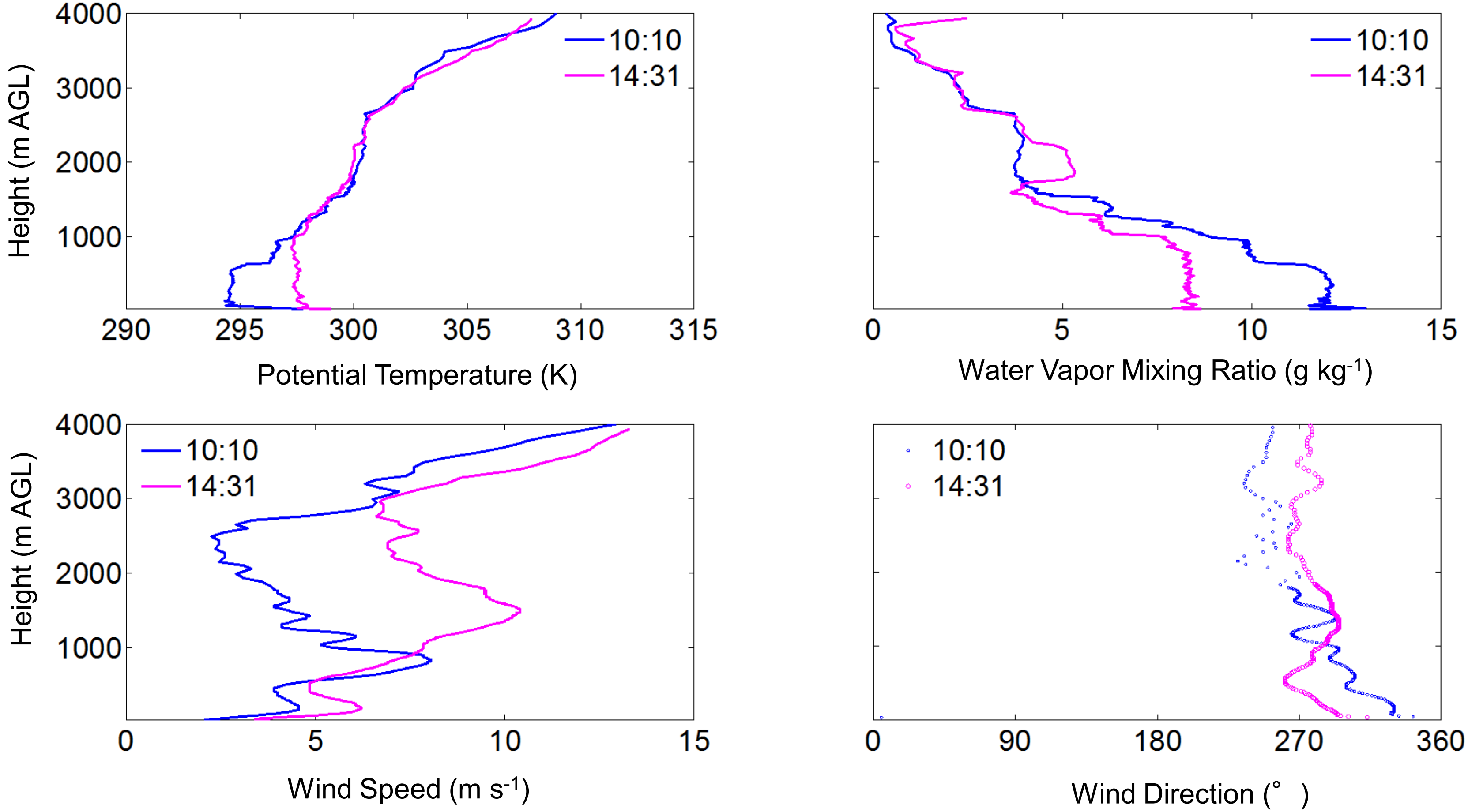
Experimental Design



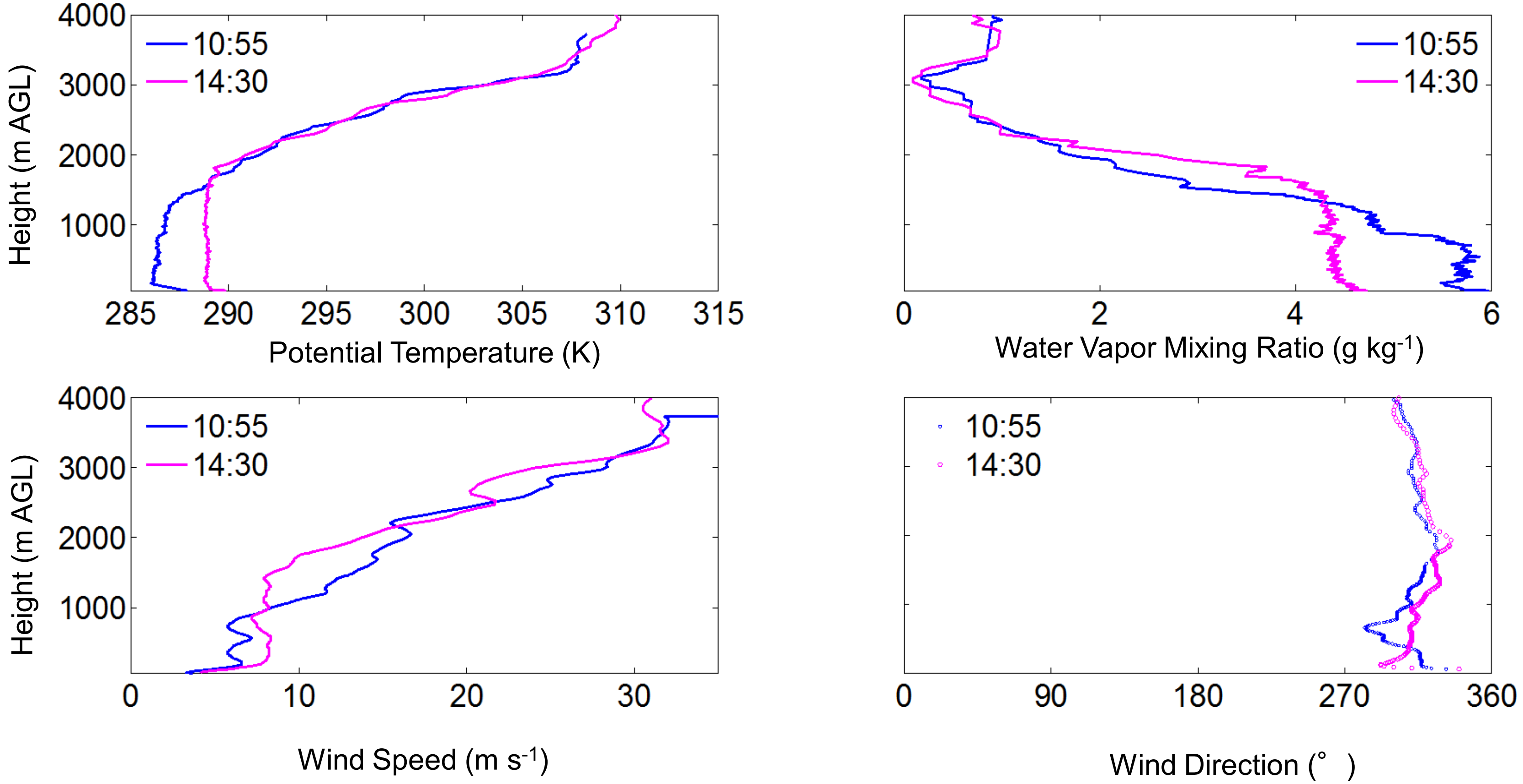
CSU-MAPS: Ambient Meteorology (S7-S9)



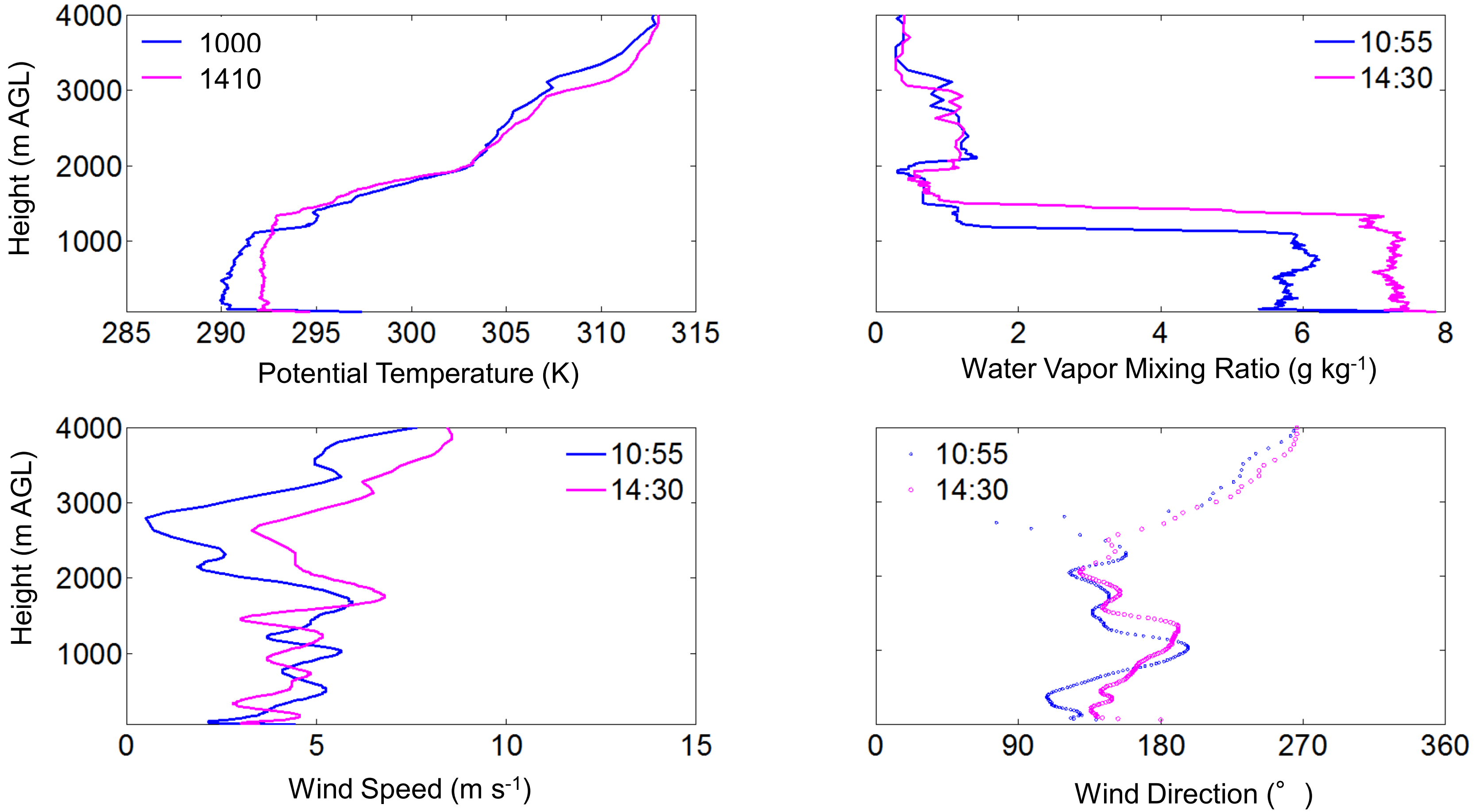
Sounding: 4 Nov 2012



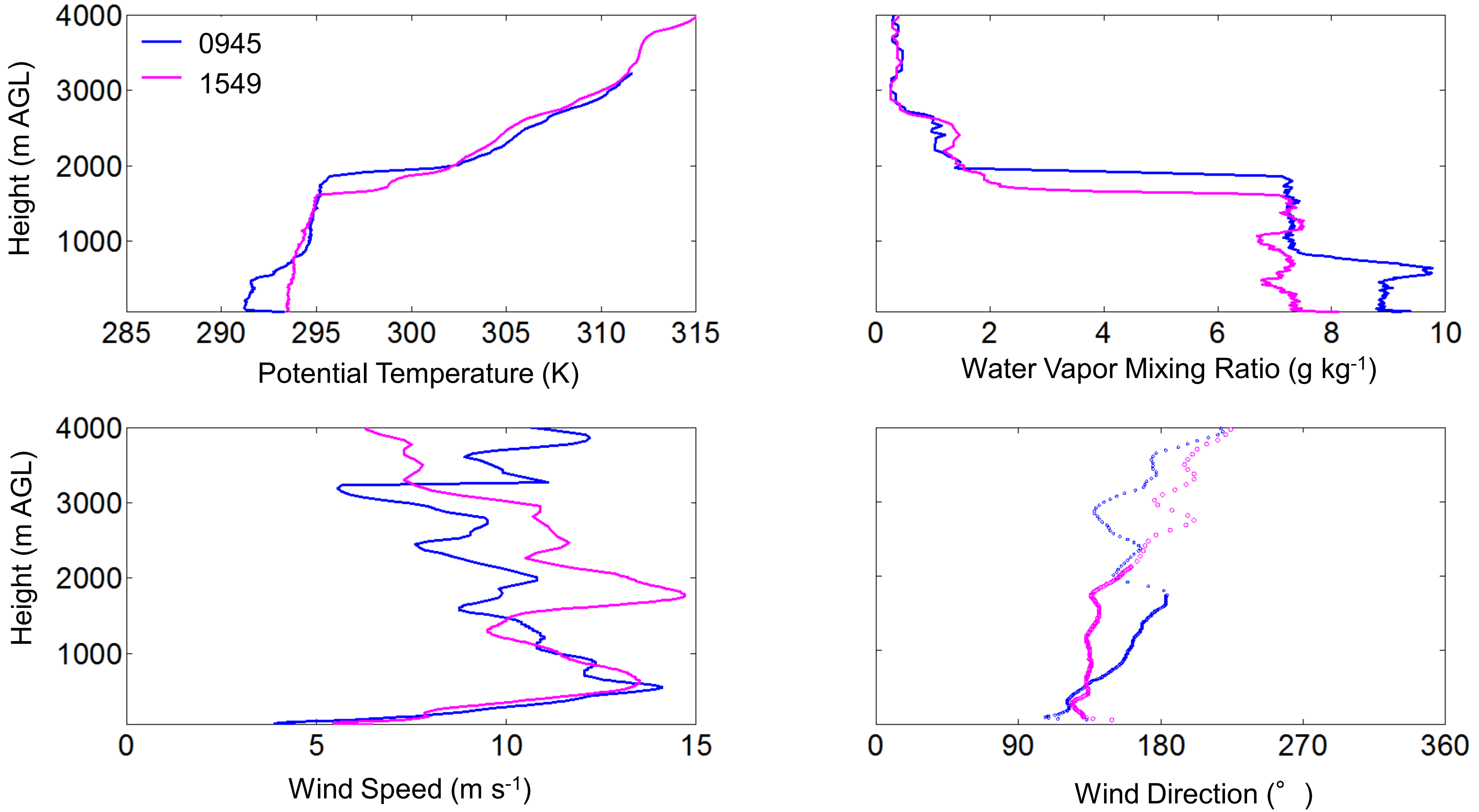
Sounding: 7 Nov 2012



Sounding: 10 Nov 2012



Sounding: 11 Nov 2012



Micrometeorology of Fire Front Passage (FFP)

Meteorology at the fire front do not represent ambient conditions.

The FFP is characterized by:

- Increase in velocity field *u, v, w*, and temperature, *T*.
- Surface wind reversal
- Peak in turbulence and sensible heat flux.
- Minimum in atmospheric pressure
- Strength of each determines fire-atmosphere coupling.

Tower Instrumentation

Two 3-D sonic anemometers: (ATI, SATI-Sx probe) 2 m and 6 m AGL

Fine-wire thermocouples (Omega, Inc), every 1 m, 1-9 m AGL

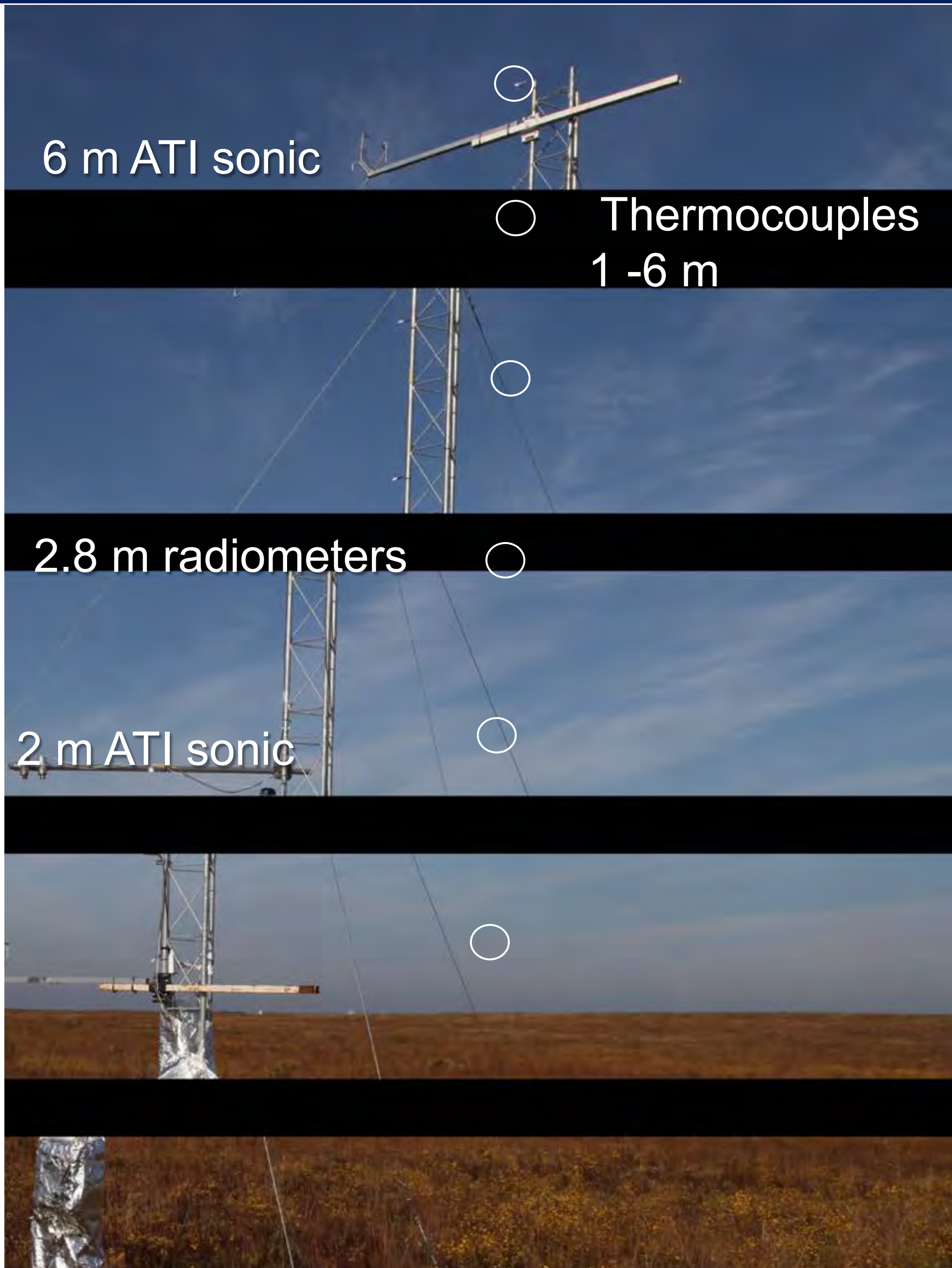
Hukseflux SBG-01: total heat flux radiometer: 2.8 m

Medtherm 64: radiative heat flux radiometer: 2.8 m

Campbell Scientific Inc, CR3000 data logger, CFM card reader, 2 GB card

Clock locked to GPS

Raw data sampled at 10 Hz;
TCs at 5 Hz



Data Processing: 10 Hz time series

Raw 10 Hz time series of u,v,w,t_s are:

1. Despiked using 3σ for pre, and post FFP

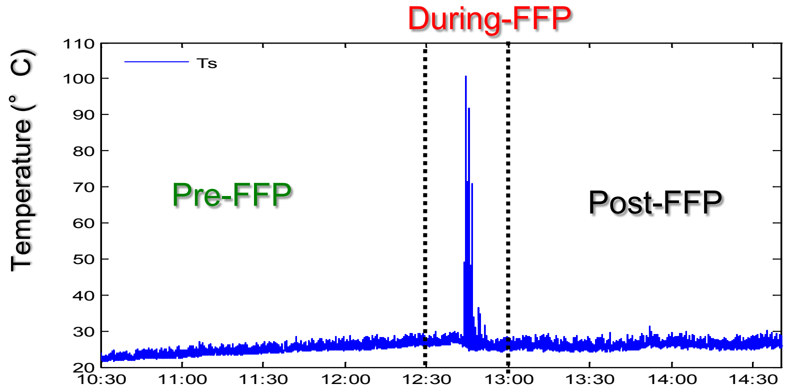
1. FFP is visually inspected (or despiking is applied).

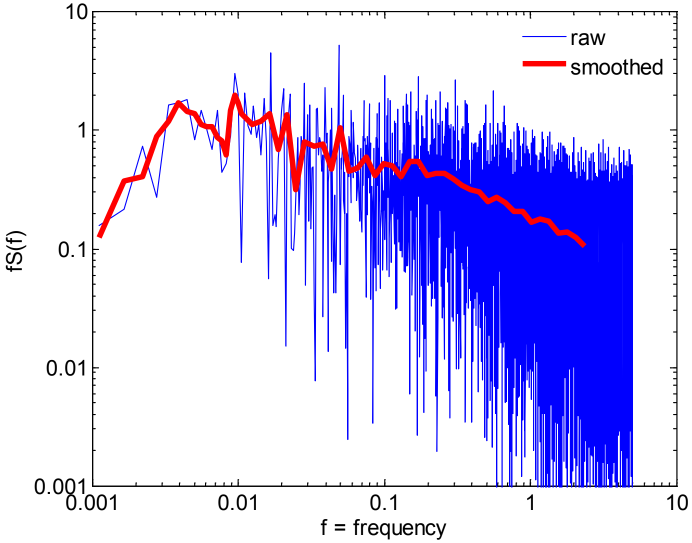
2. 30 min *u, v* rotated into stream-wise, cross-wind directions; *w* is tilt-corrected (planar-fit method).

1. 15 min average is used to calculated perturbations for turbulent statistics

Data Processing: Turbulence Spectra

- Wind velocity and temperature (10 Hz):
  - U: mean wind direction
  - V: lateral wind direction
  - W: tilt-corrected, vertical velocity
  - Ts: sonic temperature
- Define Pre-, During-, Post-**Fire Front Passage** (**FFP**)
- Fast Fourier Transform (FFT) / Wavelet Transform





Data Processing: Turbulent Statistics

Turbulent Kinetic Energy (TKE) is the sum of velocity variances:

$$TKE = \frac{1}{2}\left(\overline{u'^2} + \overline{v'^2} + \overline{w'^2}\right)$$

Turbulent Sensible Heat Flux (Hs) is calculated by eddy-covariance from

$$H_s = \rho c_p \overline{w'T'}$$

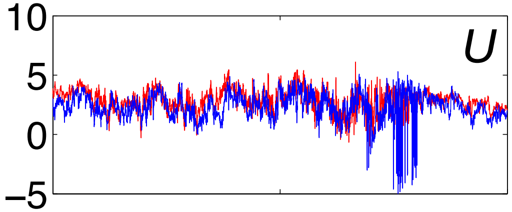
To isolate FFP, 1 min averages are calculated

Tower Time Series: 10 Hz processed

S3

S4

S5



V

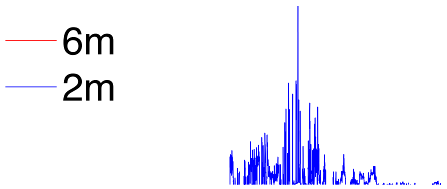
(m s-1)

W

(m s-1)

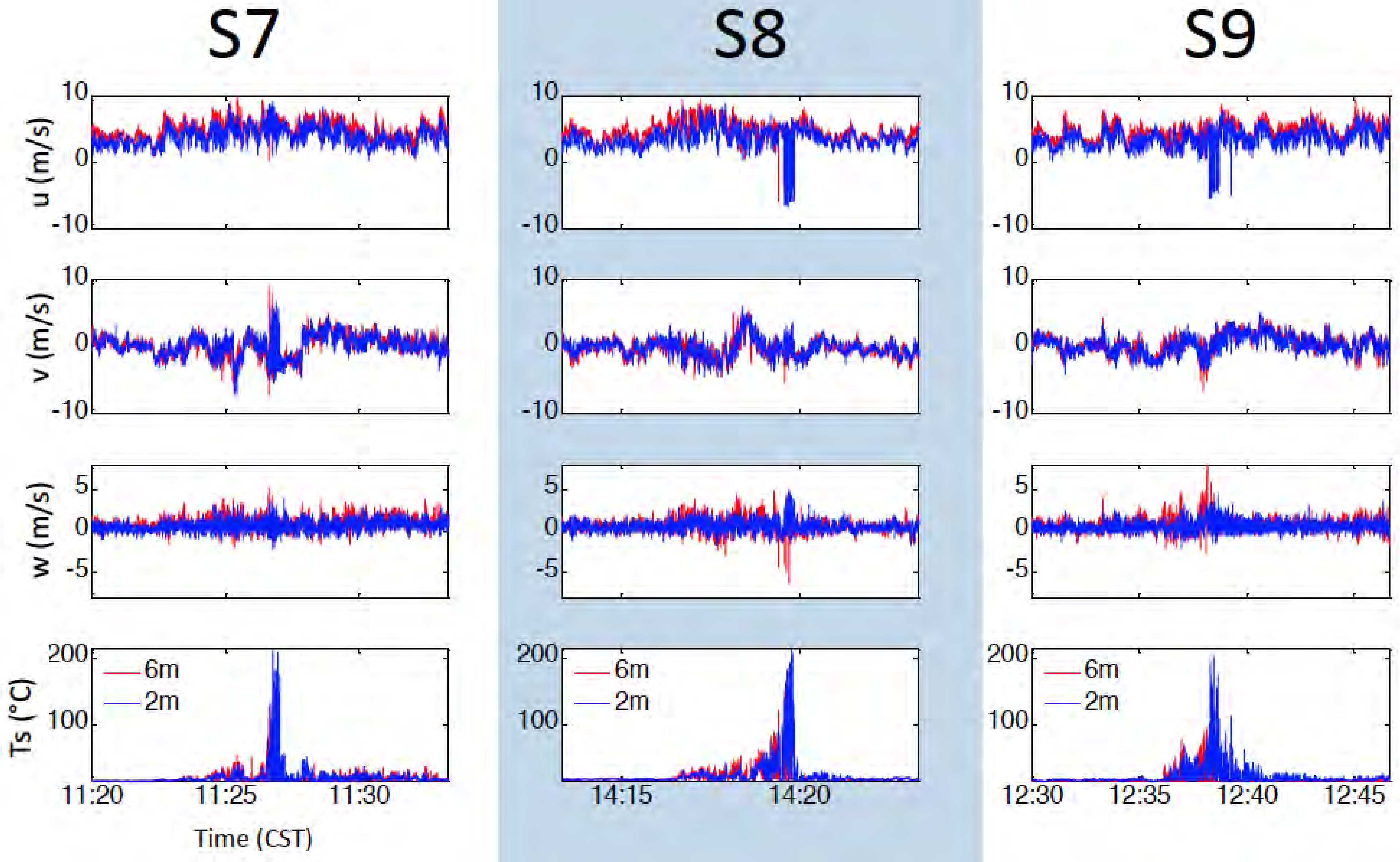
Ts

Temperature (C)

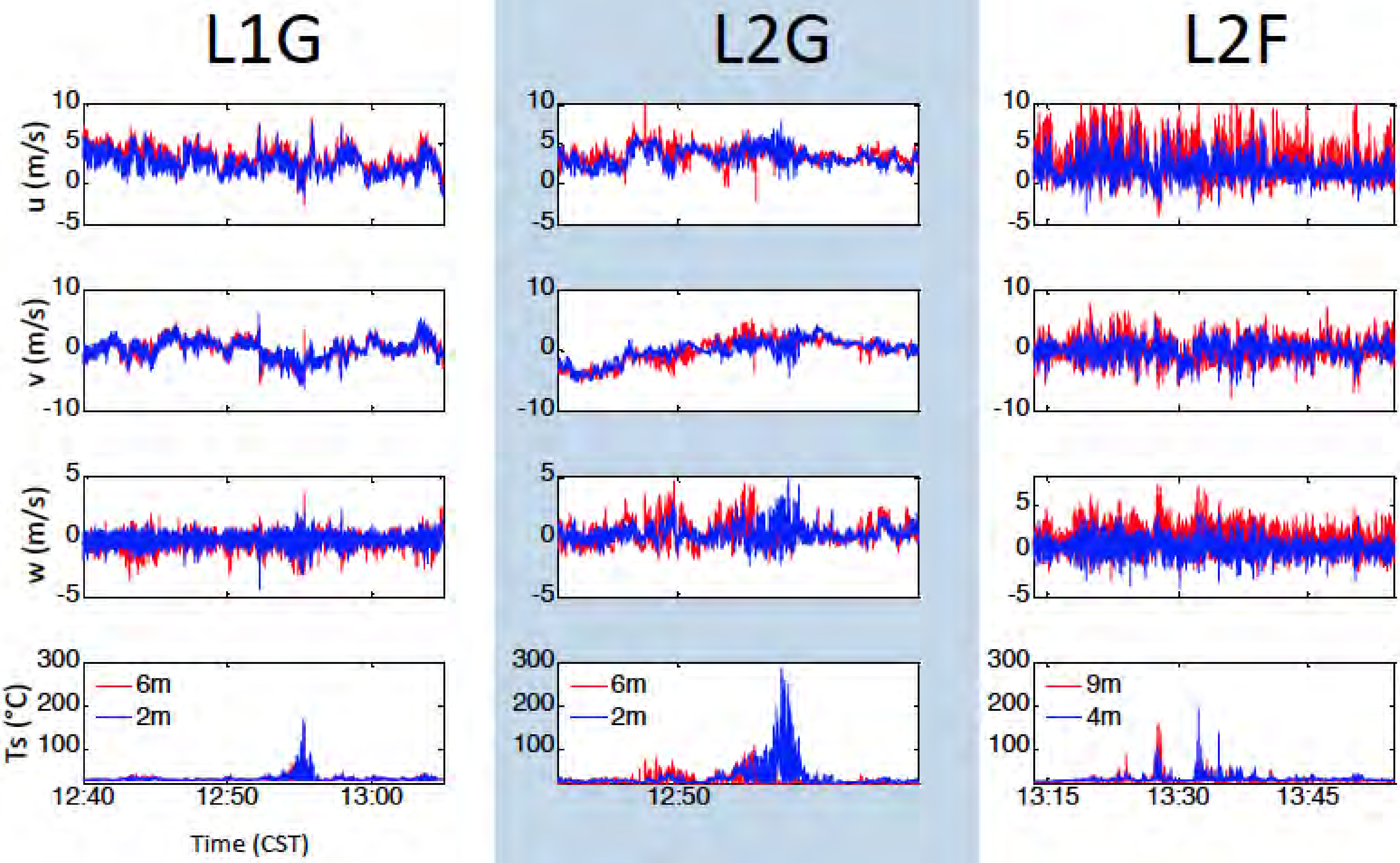


Time (CST)

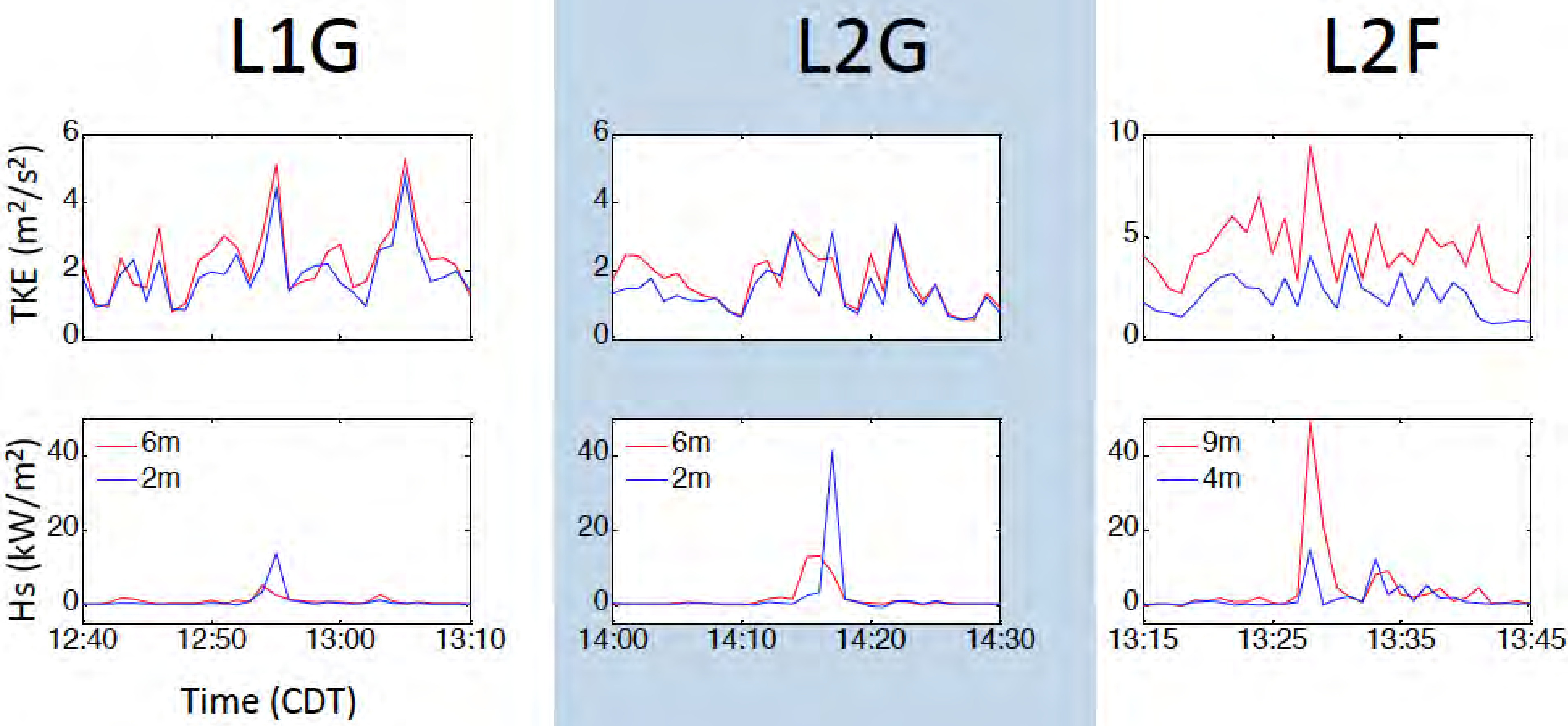
Time Series: 10 Hz processed



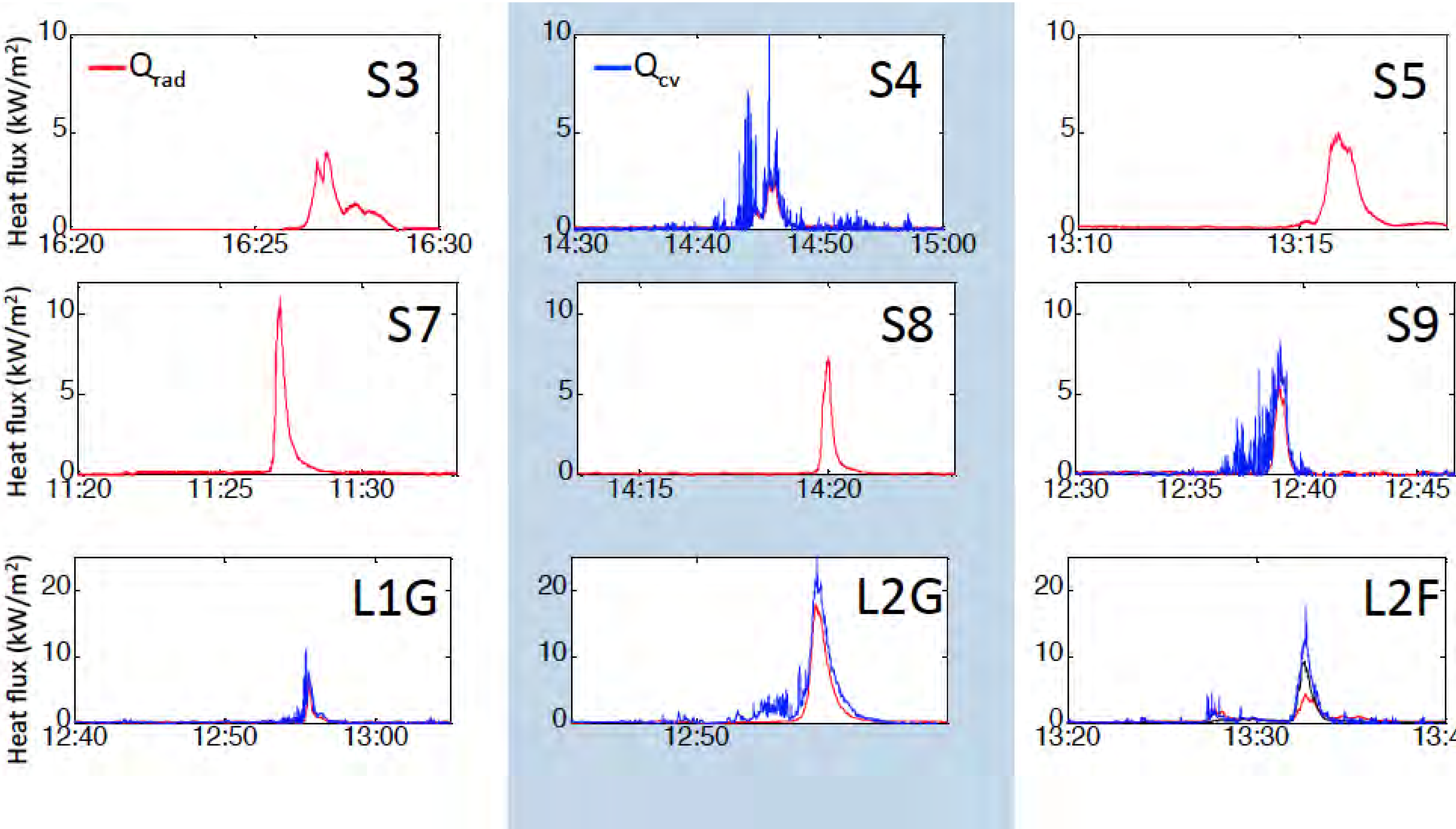
Tower Time Series: 10 Hz processed



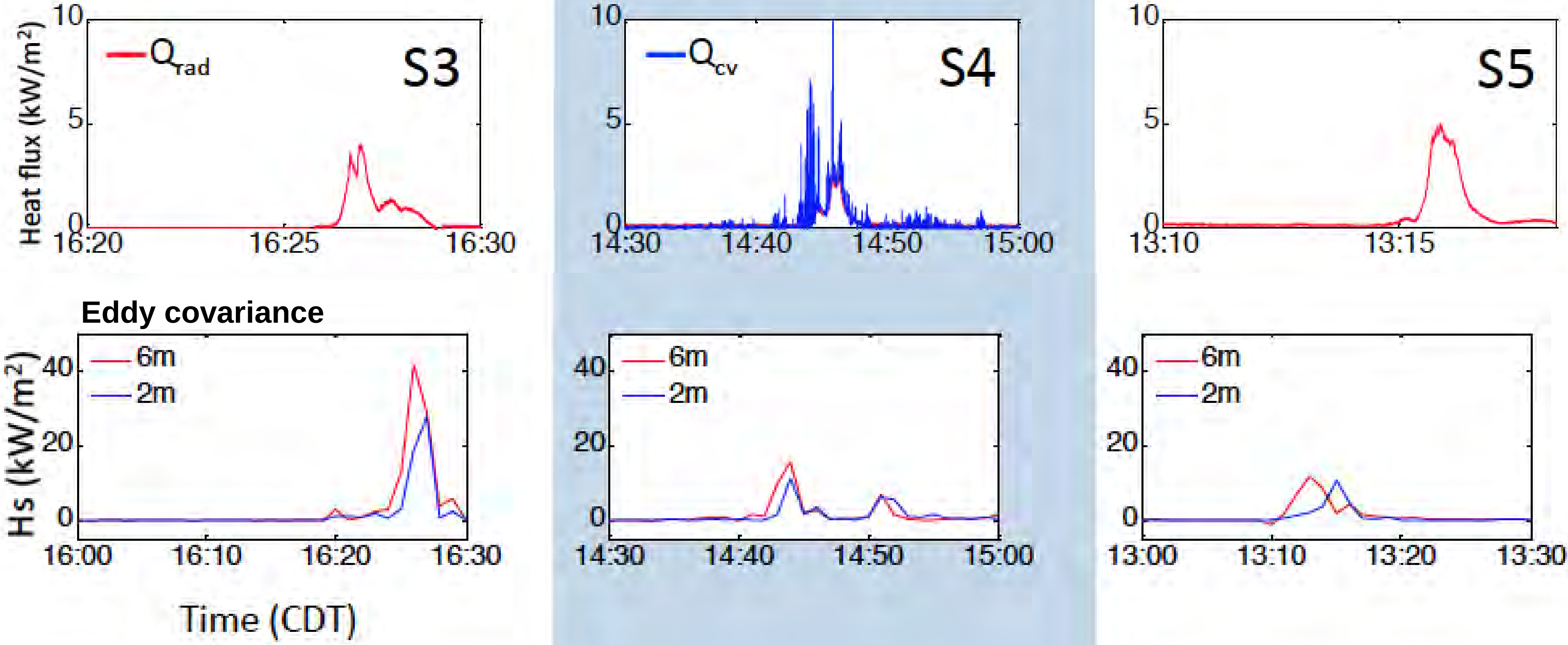
Turbulence Kinetic Energy and Heat Flux



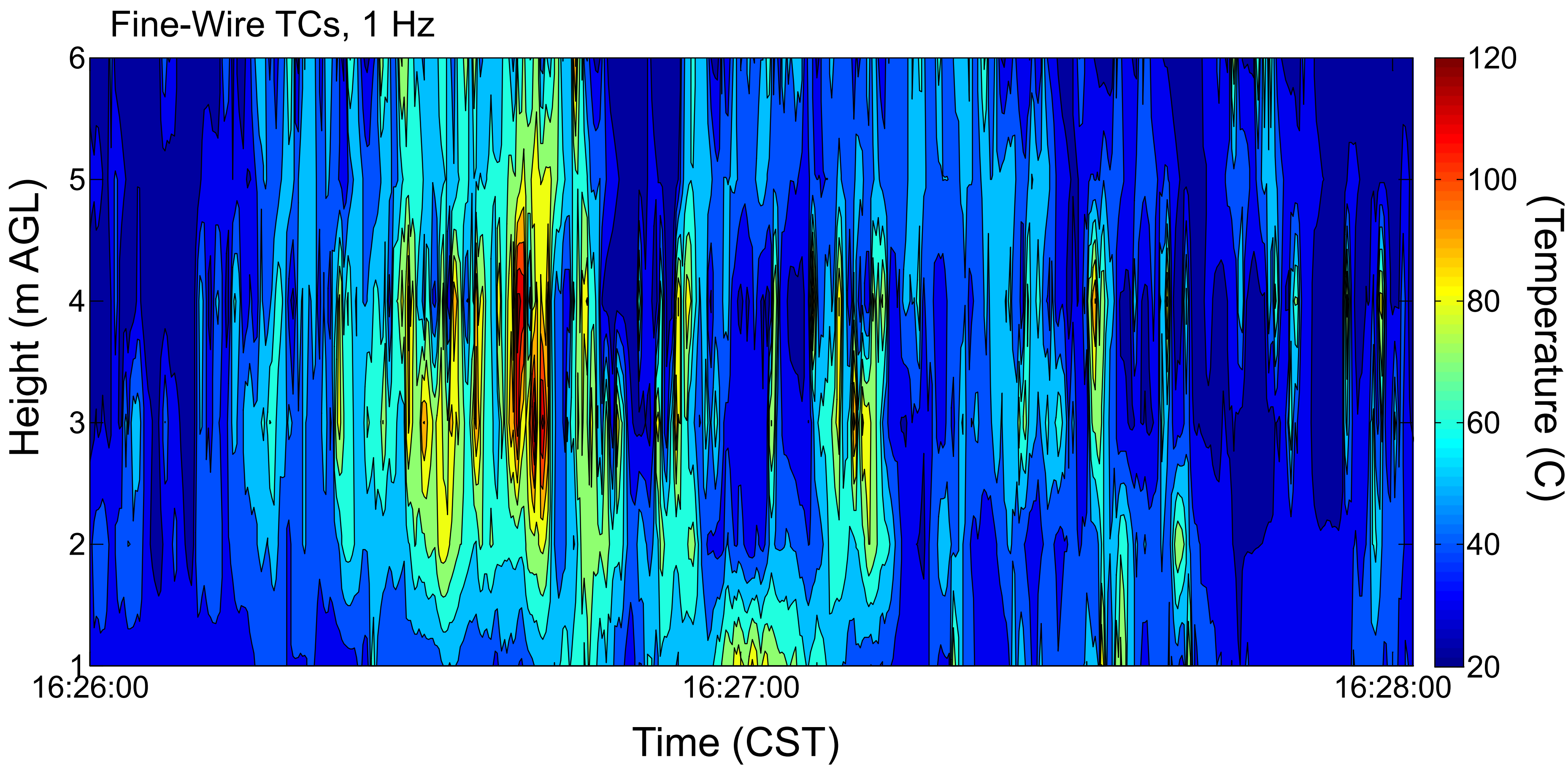
Convective and Radiative Heat Fluxes



Comparison of Heat Fluxes: Eddy Covariance vs. Radiometric Measurements

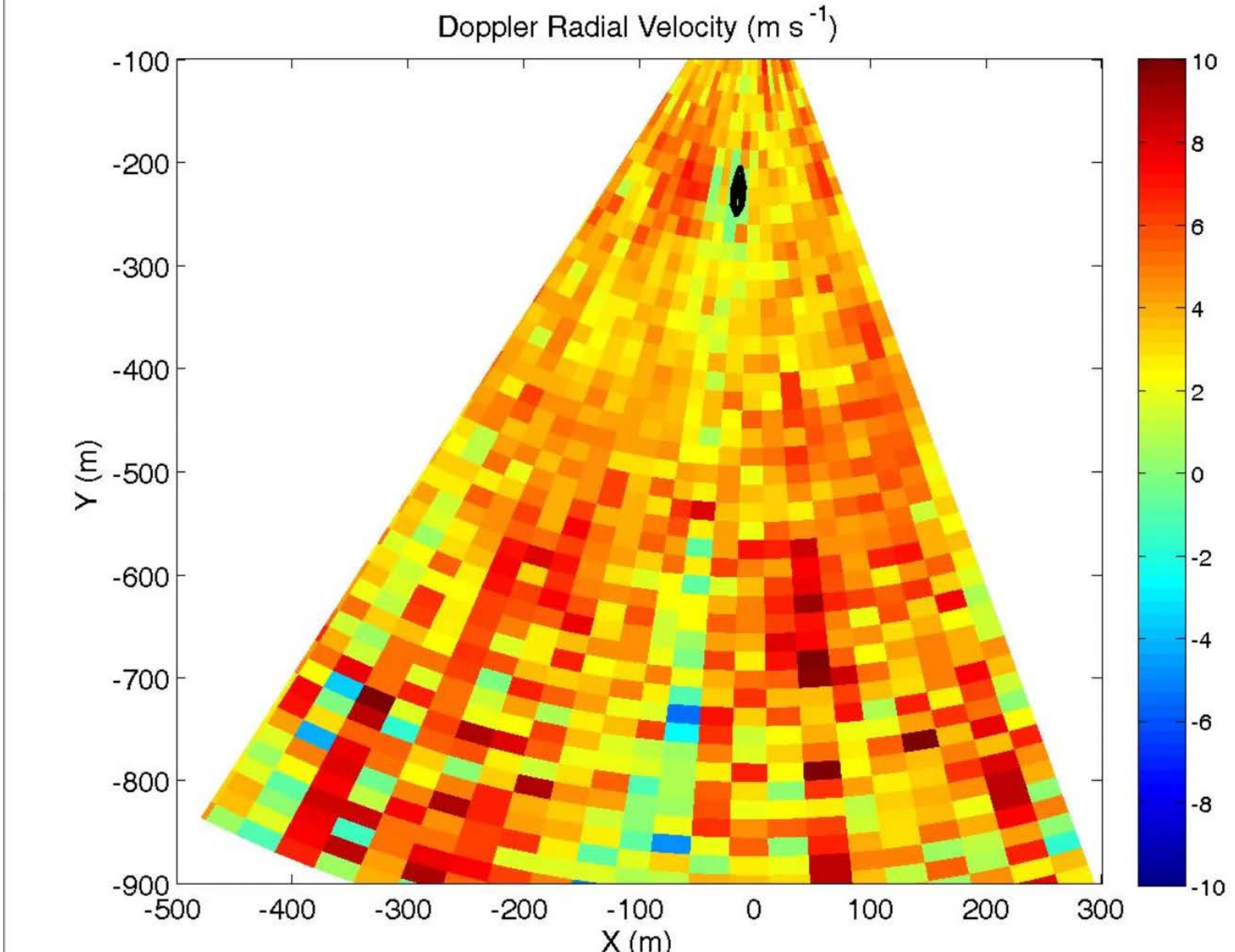


Near-Surface Thermodynamic Plume Structure (Plot S3)



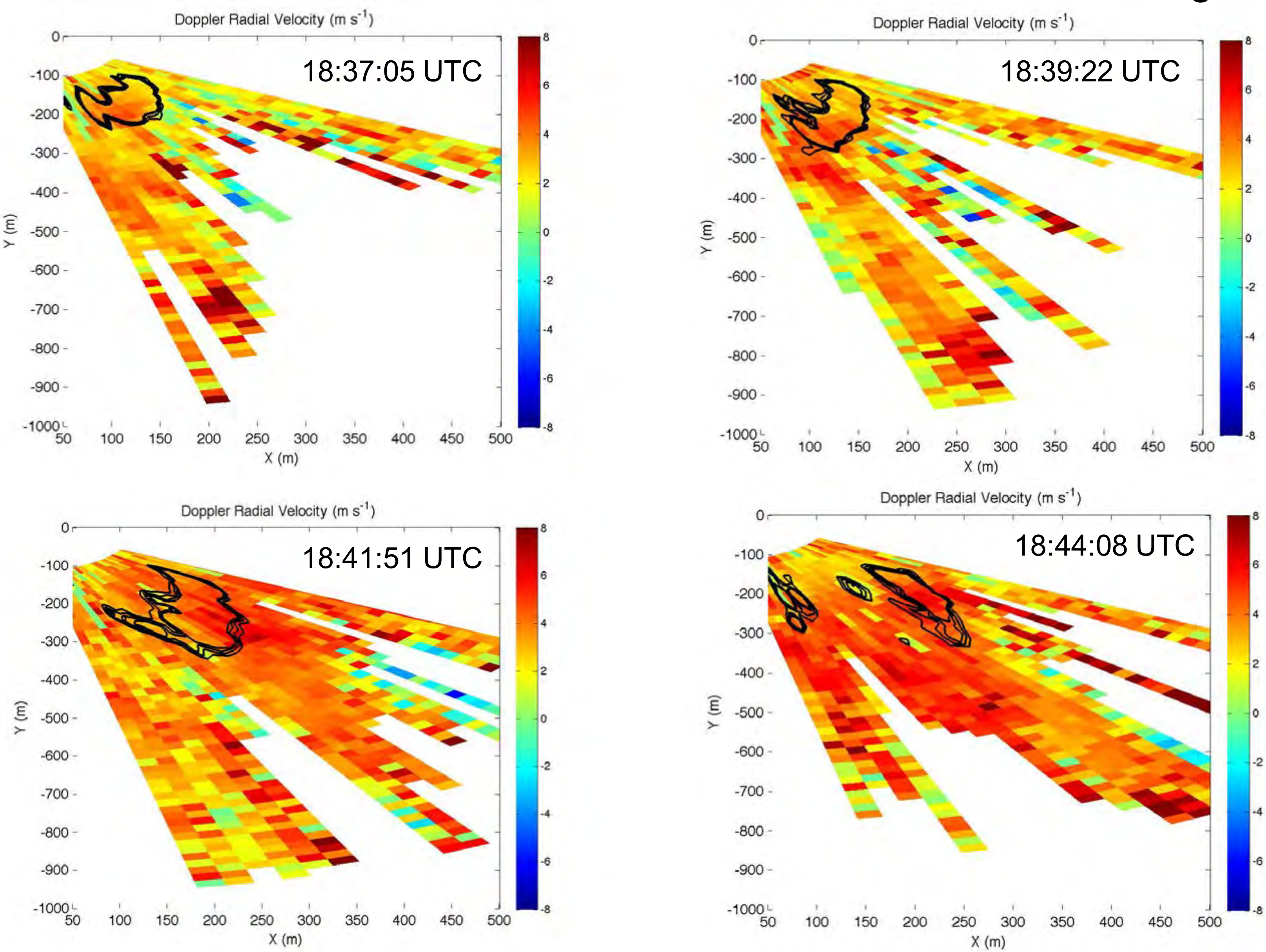
Doppler Lidar deployed during S7

Doppler Radial Velocity and Backscatter: S7

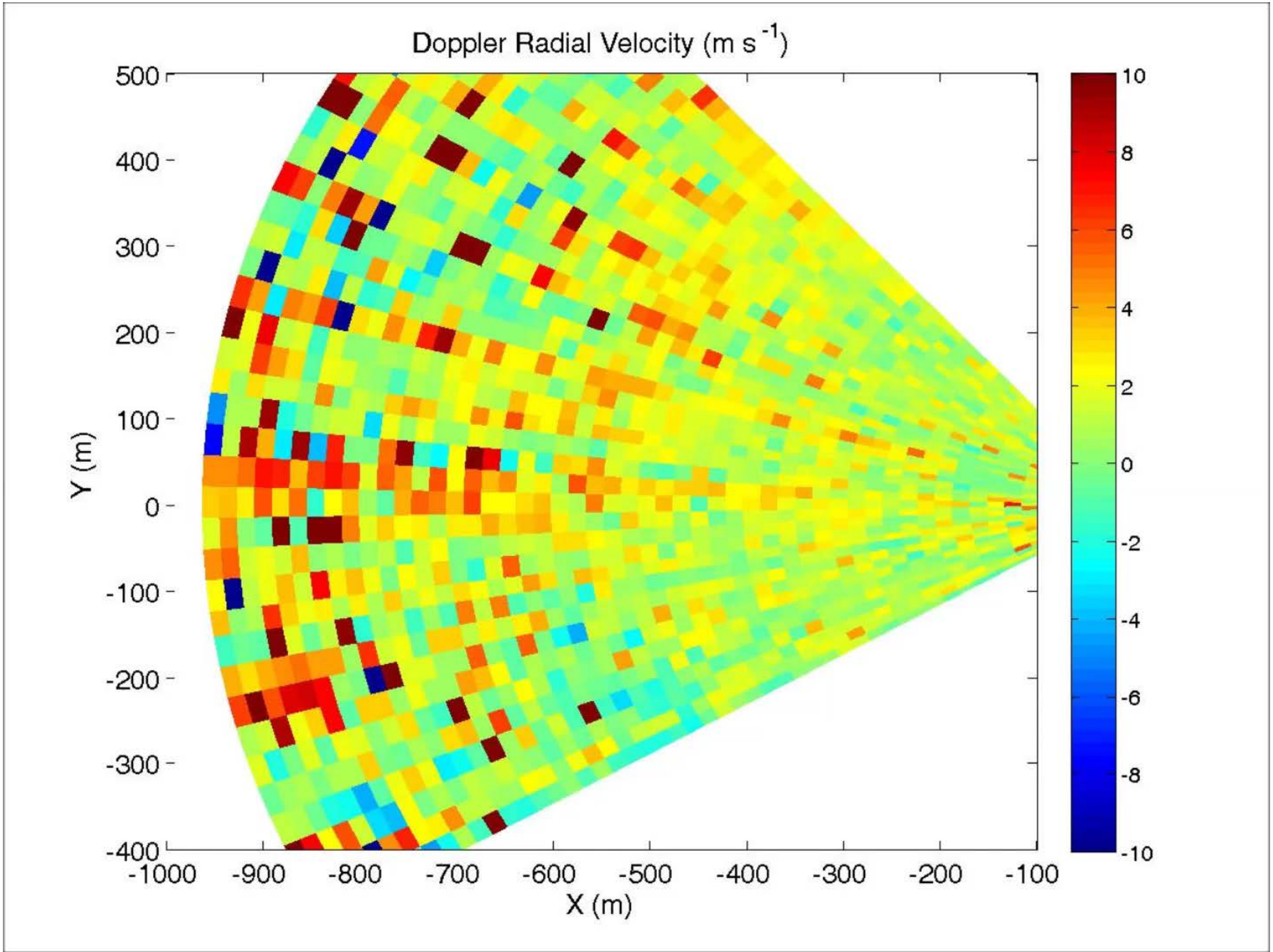


Doppler Radial Velocity and Backscatter: S8

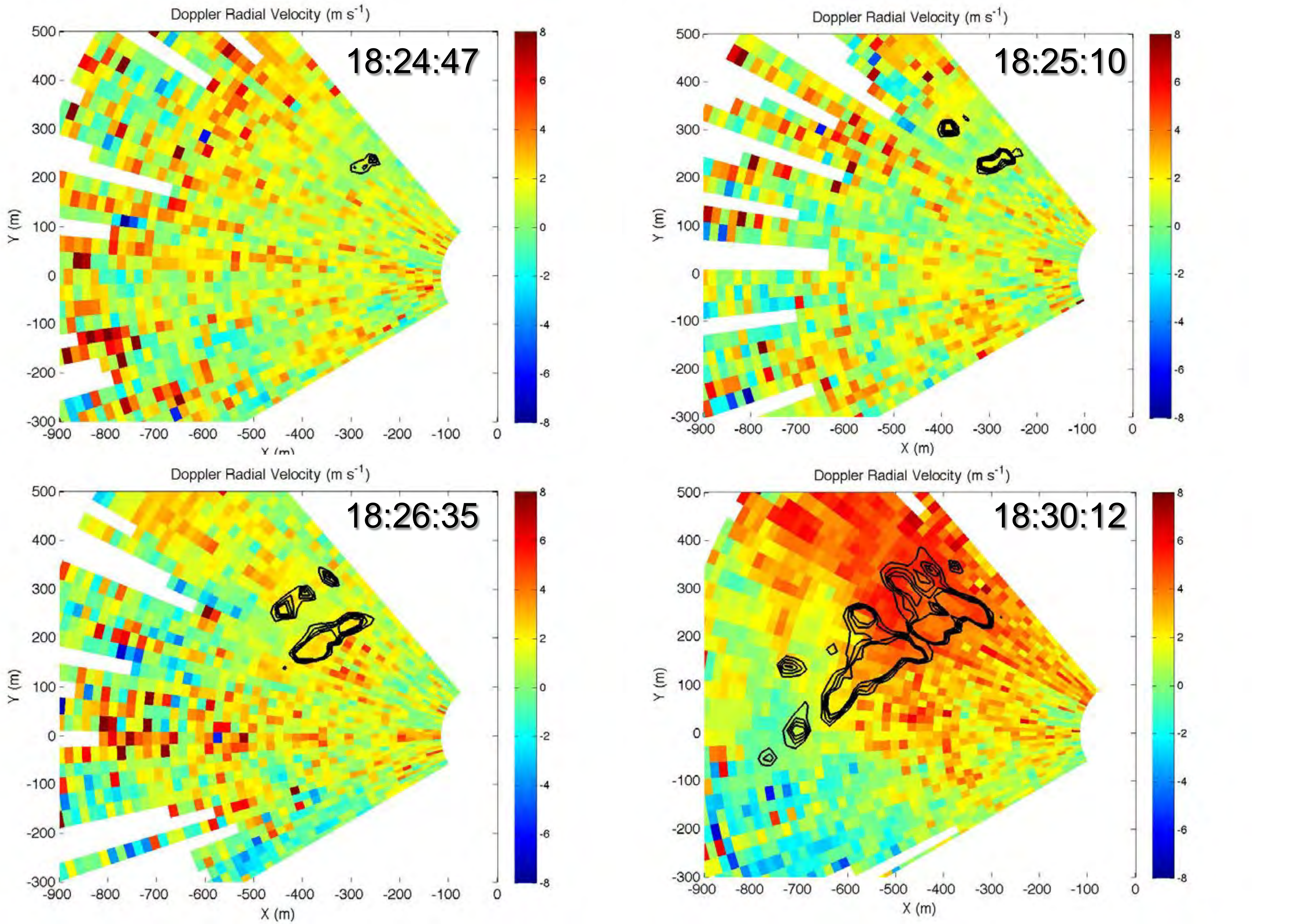
Elevation angle: 2.5°



Doppler Radial Velocity: LG2



Doppler Radial Velocity: LG2



Conclusions

- Overall, data quality is high!

- In situ tower data shows FFP structure and fire-atmosphere coupling
- Doppler Lidar scans are able to track plume boundaries
- Lidar beam able to penetrate plume, but some attenuation occurs downstream

Future work

1. Correlate lidar plume boundaries with UAS fire front
2. Calculate turbulent spectra from time series data
3. Compare heat fluxes to others measured

Acknowledgements

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